Skin follicle development in South African (SA) and SA x New Zealand Angora goats

A.L. PARRY, A.F. DEATH, H.B. DICK, C.M. MILLER AND A.J. CRAVEN

New Zealand Pastoral and Agricultural Research Institute, Flock House Agricultural Centre, Private Bag 1900, Bulls, New Zealand.

ABSTRACT

Breed, sex and birth rank differences in follicle density and *S/P* ratio were examined for South African (SA) and SAxNZ Angora goats. All primary (*P*) follicles but few secondary (*Sf*) follicles were mature at birth. Density of mature secondary (*Sf*) follicles increased by 150% and 250% in the first month after birth, in SA and SAxNZ kids respectively. Change in *P* and *Sf+Si* follicle density followed an asymptotic slope. *S/P* ratio was 8.4 at birth and 9.9 at 6 months. Breed differences were apparent early in life but were not persistent to 6 months of age. Sex by birth rank interactions at 4 and 6 months of age showed that single males had an advantage over twin males in *P* and *S* density ($P<0.05$) while twin females had an advantage over single females ($P<0.05$). These differences are a likely result of differences in nutritional advantage and changes in body size. *S/P* ratio was unaffected by breed, sex and birthrank. The results show that initiation of *S* follicles after birth was likely but inconsequential. Follicle density and *S/P* ratio do not explain breed differences in fibre and kemp production. Comparisons with other studies suggest that the SAxNZ Angora would have a higher *S/P* ratio than the NZ Angora.

Keywords: Angora goat, skin follicle development, breed, birth rank, sex.

INTRODUCTION

South African (SA) Angora goats produce heavy fleeces with low levels of kemp and medullation. They are a new genetic resource in New Zealand and it is pertinent to evaluate their fleece production potential in particular comparing them with present New Zealand (NZ) Angoras and SA x NZ crosses.

An understanding of fleece production can be gained from a histological study of the skin examining follicle density and secondary to primary follicle (*S/P*) ratio. Follicle density is a major factor controlling the fineness and density of the fleece. Information on the rate of (post-natal) follicle maturity and follicle densities in SA Angoras and their crosses can determine the contribution of these factors to the high fibre producing potential of these goats. Further to this, the study of post-natal follicle development reveals when the follicle population is mature (fibre-producing).

Studies on the post-natal development of follicles in the skin of the SA Angora goat describe changes in follicle maturity with age on small numbers of animals (Dreyer and Marincowitz 1967; Wentzel and Vosloo 1974, 1975) and contain no information on breed or birth rank comparisons. The objectives of the present study were to examine breed, sex and birth rank differences in the development and number of primary and secondary follicles in Angora goats of SA origin and their crosses in New Zealand.

MATERIALS AND METHODS

This study was undertaken in 1989 at the Flock House Agricultural Centre, Diamond Fibre Ltd. quarantine station, on 58 kids from straight-bred SA Angora goats and 39 kids from NZ Angora does mated to SA bucks. No pure NZ Angoras were available for study in quarantine. The SA kids were born on either 27.10.89 or 10.11.89 and SAxNZ kids were born later (19.11.89). This meant that at sampling dates after birth, the exact age of each group varied but was referred to as, for instance, "the 1 month sample". Because of this, corrections for age were incorporated into the statistical analyses (see section below).

Kids were skin sampled and weighed within 24 hours of birth and at 1, 2, 4 and 6 months of age. Sex and birth rank were recorded and does and kids were grazed together on mixed pasture. Skin samples were collected from the right midside using the snip biopsy technique (Parry *et al.* 1992) after injection of local anaesthetic (2 ml Lopaine - lignocaine hydrochloride U.S.P. 20mg/ml) and stored in 10% phosphate buffered formalin.

Histology

Skin biopsies were wax embedded, sectioned at 8 microns and stained using the "Sacpic" method (modified from Auber 1952). Sections were examined using a light microscope attached to a video screen, which enabled the measurement of follicle densities.

Measurements

Follicle density measurements as follicles/mm^2 were taken for (i) mature primary follicles (*P*), (ii) mature secondary follicles (*Sf*) and (iii) immature secondary follicles (*Si*), and assessed on one skin section from each animal at each age. Density was measured by counting the number of follicles in a prescribed area on the video screen and correcting for magnification. Six fields (on the video screen) were counted on each skin section and averaged to give three density measurements (*P*, *Sf*, *Si*) for each sample. From these the ratio of secondary to primary follicles was calculated and expressed as *S/P* ratio where $S = Si+Sf$.

Statistical Analysis

The effects of breed, sex and birth rank on *P* and *S* follicle density, *S/P* ratio and liveweight were examined using analysis of variance for each of the 4 separate sampling dates, birth, 1, 4 and 6 months of age (the 2 month sample was omitted from the analysis of variance due to insufficient numbers). In these analyses, age was incorporated as a covariate to correct for differences in age between individuals at each sampling time. The change in *P* and *S* follicle density over time was examined using non-linear modelling (Parsimonious Minimal and Maximal Models, SAS) to fit a curve using data from all sampling ages.

RESULTS

Follicle Development and Characteristics

All primary follicles were mature (fibre-bearing) at birth but a high proportion of secondary follicles were immature and had not reached the fibre bearing stage. Secondary follicles with fibres at birth were on the secondary margin and likely to be S originals (Hardy and Lyne 1956). Appearance of the follicle groups at birth were similar for both breeds though rates of development appeared to differ particularly over the first month after birth. SA goats showed a 150% increase in Sf density from birth to 1 month of age (41.6 Sf follicles/mm^2 to 62.7 Sf follicles/mm^2, respectively) and SAxNZ showed a 250% increase in Sf follicles over the same time (28.4 Sf follicles/mm^2 at birth to 70.2 Sf follicles/mm^2 at 1 month).

Mean *P* follicle density was highest at birth (17.4 follicles/ mm^2), decreasing by over 50% to 1 month of age (7.7 follicles/ mm^2). A slower rate of decline occurred to 2 (5.7 follicles/mm^2) and 4 months of age (3.7 follicles/mm^2), with little change to 6 months of age (3.0 follicles/mm^2).

Density of *Sf* follicles at birth was 35.7 and *Si* density was 3 times that of *Sf* density (108 follicles/mm^2). By 1 month of age, *Sf* density was far greater than *Si* density (60 vs 6.0 follicles/mm^2) with over 90% of secondary follicles having reached the fibre-bearing stage. Immature secondary follicles were still observed at 2 months (Si=1.1 follicles/ mm^2, Sf=52.2 follicles/mm^2) but not at 4 months (Sf=39.1 follicles/mm^2) of age and secondary density continued to decline to 6 months of age (28.8 follicles/mm^2). Mean *S/P* ratio at birth, 1, 2, 4 and 6 months was 8.4, 8.8, 9.3, 10.9 and 9.9, respectively.

Effects of Breed, Sex and Birth Rank

There was a significant effect of breed on both *P* and *S* follicle density showing that SAxNZ kids had higher follicle densities at 1 and 4 months ($P<0.05$) with differences between the breeds disappearing by 6 months of age (Table 1).

Sex differences in follicle density at birth showed that males had 14% more *S* follicles per mm^2 than females (155.4 vs 136.4, $\pm$4.7 follicles/mm^2). At 4 and 6 months of age there were sex by birth rank interactions (Table 2). Single males had an advantage over twin males in *P* and *S* density ($P<0.05$) while twin females had an advantage over single females ($P<0.05$).

TABLE 1: Mean follicle density (follicles/mm^2) and *S/P* ratio for SA and SAxNZ Angora goats.

	Birth	1 month	4 months	6 months
Primary				
SA	18.4a	7.3a	3.6a	3.1
SAxNZ	16.4b	8.0b	4.1b	2.9
Secondary*				
SA	149.9	60.0a	36.0a	30.6
SAxNZ	141.9	72.0b	43.4b	27.9
***S/P* ratio**				
SA	8.3	8.5	10.5	10.1
SAxNZ	8.8	9.2	11.2	9.9

* secondary = total of immature & mature follicles
Levels of significance apply within sampling age, not between ages. Different letters mean that values are significantly different at the $P<0.05$ level.

TABLE 2: Mean follicle densities (follicle/mm2) for sex and birth rank classes at 4 and 6 months of age.

	Female		Male	
	Single	Twin	Single	Twin
Primary				
4 months	3.7b	3.9a	4.0a	3.5b
6 months	2.8b	3.2a	3.3a	2.8b
Secondary*				
4 months	39.1ab	40.5a	42.1a	37.0b
6 months	27.0b	29.2a	32.4a	28.4b

* secondary = total of immature & mature follicles
Levels of significance apply within sampling age, not between ages. Different letters mean that values are significantly different at the $P<0.05$ level.

Breed, sex and birth rank differences showed in *S/P* ratio at birth and 1 month of age but there were no significant differences between these classes at later ages.

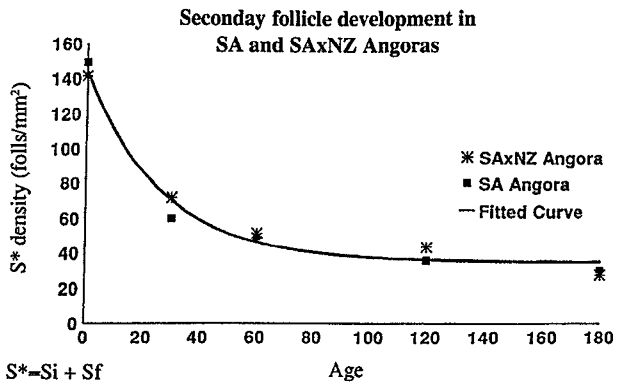
There were significant bodyweight differences and SA goats were significantly heavier than SAxNZ goats at birth and 6 months. Males were heavier than females at birth, 4 and 6 months and singles were heavier than twins, at birth, 1 and 4 months (Table 3).

TABLE 3: Mean bodyweight (kg) of breed, sex and birth rank classes.

	Birth	1 month	4 months	6 months
SA	2.5a	8.2	17.2	28.1a
SAxNZ	2.3b	7.8	16.7	20.7b
Female	2.3a	7.7	15.9a	22.4a
Male	2.5b	8.2	18.1b	26.5b
Single	2.5a	8.3	17.9a	24.9a
Twin	2.3b	7.6	16.1b	23.9b

Levels of significance apply within sampling age, not between ages. Different letters mean that values are significantly different at the $P<0.05$ level.

FIGURE 1: Fitted curve {*mean S density = 35.41 + 108.94 x e* $^{(-0.038 \times age)}$} for change in secondary follicle density over time.



Predicting Follicle Density

Non-linear regression showed that 99% of the variation in *P* follicle density and 98% of the variation in total *S* density over time was explained by the variation with age (Fig 1). Both P and S density followed similar curves with respective equations:

P density = $3.32 + 13.91 \times e^{(-0.034 \times age)}$ and *S density* = $35.41 + 108.94 \times e^{(-0.038 \times age)}$.

DISCUSSION

Follicle Development

This study has shown that numbers of immature *S* follicles were very high at birth, though most *S* follicles were mature by 1 month of age. A small proportion of immature secondaries (2%) was noted at 2 months of age though none were observed thereafter. An apparent increase in *S/P* ratio with time in the present study, and the absence of immature primaries, show that some post-natal secondary follicle initiation is likely between 1 and 4 months of age. Wentzel and Vosloo (1975) suggested that although the secondary follicle population of SA Angoras is mainly initiated during the fourth month of gestation, further initiation occurs after birth and the majority of these follicles reach functional maturity between 14 and 120 days after birth, with all secondary follicles producing fibres by 4 months of age. Dreyer and Marincowitz (1967) found no change in *S/P* ratio from 3 to 6 months of age in SA Angoras and reported similar 6 month *S/P* ratios to those found in this study.

Change in mature follicle density after birth is related to the changing size of the animal and therefore to bodyweight. A high density of functionally mature follicles at birth will naturally decrease as the animal grows and this decline is asymptotic, as depicted by the fitted curve for *P* follicles. The addition of *Si* follicles to *Sf* follicles resulted in data which fitted a similar curve to that for *P* follicles.

Bodyweight differences between the different classes (breed, sex and birth rank) showed that in some cases heavier kids had higher follicle densities. Male singles had higher follicle densities than male twins. These results could reflect a nutritional advantage of male singles over male twins though female twins, which were lighter than female singles at 4 months, had higher follicle densities. In the latter case, female twins being lighter may have had less skin surface area for follicles to cover. The use of a follicle number index (FNI) as developed by Parry et al (1992) for the cashmere goat may go part way to removing surface area differences by multiplying follicle density by the metabolic liveweight of the individual. However, the use of metabolic liveweight to estimate surface area of the goats in the present study requires additional animal measurements and statistical analysis to further test the "FNI theory" on the Angora goat.

Studies with sheep have shown that sex and birth rank differences in follicle density rarely persist into adulthood (Corbett 1979) though differences in follicle development (Doney and Smith 1964) and follicle density (Sumner and Wickham 1970) between single and twin lambs and have been recorded up to 13 weeks of age. Parry et al (1992) found persistent differences in follicle number index (FNI) between female and male and twin and single cashmere goats up to 10 months of age, though differences in *S/P* ratio between female and male SA Angoras studied by Dreyer and Marincowitz (1967) were evident at 3 months of age only.

Aspects of this study which are of primary interest to the farmer are any persistent effects of breed, sex and birth rank on *S/P* ratio and thus fleece type and density. The results show that these factors did not have persistent effects on the *S/P* ratio of the goats studied.

Follicle Populations of SAxNZ and NZ Angoras

In a separate study of the follicle characteristics of the same NZ Angora flock which provided dams for the present study, Jonen (1991) reported a mean adult *S/P* ratio of 8.11. This suggests that the *S/P* ratio of 9.87 for the SAxNZ Angora is a notable improvement on the NZ Angora. Winklmaier (1983) also reported comparatively low adult *S/P* ratios (7.0).

Fleece Production of SA, SAxNZ and NZ Angoras

A recent study of fleece production in SA and NZ Angoras and their crosses (S-A.N. Newman, unpublished) in quarantine at Flock House showed that greasy fleece weights at 6 months of age were highest ($P<0.05$) for SA goats and that SA x NZ had a higher ($P<0.05$) fleece weight than pure NZ goats (1.00 vs 0.68 vs 0.5 kg, respectively). These fleece weight differences were found at 12 and 24 months of age. The *S/P* ratios in the present study do not explain the higher fleece production capability of the SA goats over the cross-breds and other factors such as the fibre producing capacity of individual follicles must be considered when explanations for breed differences are sought. Newman's study also showed significantly higher levels of medullation and kemp in crossbred goats compared to pure SA Angoras. The present study shows numbers of primary follicles, which normally produce kemp fibres, are similar for the SA and SA x NZ kids.

In conclusion this study suggests that the South African genes are likely to have a positive influence on the follicle population in their crosses with NZ Angoras and show an increased *S/P* ratio over the average NZ Angora. SA Angoras are heavier than SAxNZ crossbreds at 6 months and males show a definite advantage in weight over females. Further investigation is required to establish the effect of bodyweight on follicle density and to determine a suitable method to correct for surface area changes in these goats.

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